very few cases of small-pox are met with, it is impossible (during these periods) for medical men to make themselves familiar with the exact appearances by which they can accurately diagnose small-pox. It is only during periods of epidemic that medical students and practitioners are able to become familiar with the disease. Efficient sanitary administration is undoubtedly valuable because of the greater resistance that patients who are in good health undoubtedly exhibit against the attacks of all diseases, but it can never be hoped that the directly infectious diseases, such as small-pox, measles, and whooping cough, can be diminished by the most stringent sanitary measures, in the same proportion as typhus and the plague have been, and as cholera and typhoid are being reduced. As regards isolation and quarantine, it is evident, of course, that if every case of small-pox could be isolated at the time that infection took place, and if every case could be detained in quarantine-isolation at the part at which it occurred, small-pox might now be stamped out; but even this position could only have been reached by the aid of vaccination, as without doctors and nurses protected by vaccination or previous attacks of small-pox, it would be impossible to find attendants for these isolated patients. But the whole question of stamping out by these measures without vaccination, is so utterly absurd when the conditions under which the disease is generally spread are taken into consideration, that it is really startling that they should have been suggested as capable of taking the place of vaccination, however valuable they may be as accessory factors. One writer, commenting on the example which Leicester is stated to afford of the value of strict isolation, points out, "that vaccination was carried to nearly every one who was thought to have any chance of coming into contact with the disease, and that nearly every member of the hospital staff gladly accepted re-vaccination." The Commissioners reporting on this point state "that at Leicester, the region of isolation and sanitation, two vaccinated children under ten were attacked, neither of whom died; of unvaccinated children of a similar age, 107 were attacked, of whom fifteen, or 14 per cent., died. Of vaccinated persons over ten years of age, 197 were attacked, of whom two died, or 1 per cent.; of the unvaccinated at a similar age, 51 were attacked, of whom 4, or 7·8 per cent., died." In the case of the hospital staff at Leicester, we have a most striking proof of the efficacy of vaccination. On page 82 of the Report, par. 319, we have the following: "At Leicester, at the end of the year 1892, the staff at the hospital consisted of twenty-eight persons. Fourteen of these had either previously had small-pox, or had been re-vaccinated before the outbreak. Eight others were vaccinated at the time of the outbreak. The remaining six, although they had not previously been re-vaccinated, refused to submit to the operation. During the outbreak there was an addition of twelve to the staff dealing with small-pox cases. These were all re-vaccinated, and none of them contracted small-pox. Out of the twenty-eight, six were attacked by the disease, of whom one died. Five of the persons thus attacked, including the one fatal case (the person in whose case the disease was fatal was said to be of intemperate habits), were amongst the six persons who had refused to be re-vaccinated, though in the case of one of the five consent was afterwards given to the operation, but it was only performed on the day that she showed premonitory symptoms of small-pox. The sixth case, a mild one, was that of a nurse who had been re-vaccinated ten years before." Dr. Gayton gives a similar but even more striking instance in connection with the Homerton Small-pox Hospital. The statistics given in connection with the small-pox ship hospitals in connection with the Metropolitan Asylums Board during the twelve years, 1884–1895, are also very conclusive. Amongst the attendants, varying in number from fifty in one year to 300 in another, there have only been three years out of the whole twelve in which cases of small-pox have occurred. In 1884, there were four cases among 283 attendants; in 1892, two cases among 138 attendants; and in 1893, six cases among 230 attendants. These were in close attendance upon small-pox patients in the hospital ship; all had been re-vaccinated, but in six out of the twelve cases where small-pox occurred it developed within fifteen days of admission to the ship, so that the small-pox infection and the introduction of the vaccine matter had taken place at the same time, or, as in at least two cases, the vaccination had been preceded by the small-pox infection. These are most remarkable figures, and offer evidence that well-vaccinated persons may be brought into very close contact with small-pox patients without running more than a minimal risk of contracting the disease; on the other hand, even the most careful isolation cannot prevent the outbreak of small-pox amongst the unvaccinated, unless the isolation takes place before the disease can be actually recognised, the infectivity making itself felt before the disease can be recognised. The report given by Mr. Allanson Picton and Dr. Collins certainly makes out a strong case for isolation and improved sanitation, but nowhere in it, as we have already said, do they put forward any evidence which can be accepted as proving that these are only of secondary value to vaccination during infancy and re-vaccination at stated periods, and we can quite understand how even Mr. Bright and Mr. Whitbread, along with others of the Commissioners, have been brought to see that it is impossible to contemplate the effect of leaving the whole of the population unvaccinated "without the utmost dismay."

(E) "As to whether any alterations should be made in the arrangements and proceedings for securing the performance of vaccinations, and, in particular, in those provisions of the Vaccination Acts with respect to prosecutions for non-compliance with the Law." In this Section we have the crux of the whole question. The course that the Commissioners have taken affords stronger proof of their belief in the efficacy of vaccination than any other recommendation they could have issued. They believe that the case for vaccination is so strong, that when their report is made public, and when people have had time to digest its contents, especially if the stimulus of alleged martyrdom be removed, that much of the opposition to vaccination will disappear, and that, as in Scotland, where proceedings against parents for the non-vaccination of their children are comparatively rare, the opposition to vaccination will gradually be broken down, and compulsory vaccination will no longer be necessary. Going on the principle that failure to comply with the vaccination laws is often the result of carelessness and desire to avoid trouble, although in justification of this carelessness an objection to vaccination may afterwards be developed, the Commissioners suggest that it should be necessary to take at least as much trouble to escape vaccination as to allow the child to be vaccinated. Conscientious objectors are to be allowed to make a declaration before a magistrate; this would be still more effective were it necessary to go before the magistrate in open court. The exact nature of the recommendations of the Commissioners, however, is a matter of very slight importance, as the general impression produced by this report must be overwhelmingly in favour of vaccination; and those who maintain, or rather did maintain, that the Commissioners were of opinion that vaccination was a failure, had either not read the report or had intentionally misunderstood it. As we have pointed out, of those who are against compulsory vaccination, even in the modified form suggested by the majority of the Commissioners, two are still so convinced of its efficacy that they sign the general report; and the other two, although maintaining that isolation and improved sanitary administration are sufficient to cope with the disease, nowhere lay down as a proposition that vaccination affords no protection against small-pox. After a careful perusal of the report we are convinced that, although this Commission has taken seven years during which to sift evidence and make its report, it has, both from the momentous issues at stake, and by the judicious nature of its finding, been thoroughly justified from beginning to end, and that the report will be accepted as one of the best ever presented to our, or to any other, Parliament.

SOME ENGINEERING ADVANCES IN SIXTY YEARS.[1]

WE meet this evening under peculiar circumstances, some of which are of much interest to every member of the empire, and others are specially appertaining to the Institution. These circumstances seem to me to mark the year 1896 as an epoch, at which your President may offer to you some remarks which will be not strictly a review of any of the various recent feats of engineering, but rather a retrospective survey of the general progress with which engineering has been and is intimately connected, and a consideration of some matters past, present, and future, which appear to me to touch closely the interests of us all as members of the profession.

The material advances which this country has made during the Queen's reign are so remarkable, and have depended so much on engineering developments and progress, that I think we, as members of that profession, may at such a time as this survey with profit the period covered between the accession in 1837 and the present time from that point of view, and endeavour to recall some of the differences in various circumstances which have so greatly affected the interests of the population.

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[1] Abstract of the presidential address delivered before the Institution of Civil Engineers on November 3, by Mr. J. Wolfe Barry, C.B., F.R.S.

No one can deny that these years constitute the most important period yet known of engineering, or that the work of engineers during this period has had most far-reaching effects upon the material interests of the inhabitants of these islands, as indeed of the world at large—whether those effects have been produced by improved means of inter-communication by land and sea, of sanitation, or of labour-saving appliances.

The rapid growth of towns has occasioned a demand, especially within the last thirty or forty years, for urban railways, tramways, bridges, subways, improved pavings, and other means for facilitating intercourse between the different districts of our large towns. It has been the cause of a great development of additional sources of water supply, of improved sewerage, of new means of lighting by gas and electricity, and, above all, has necessitated that minute and careful study of the laws of sanitation which has produced most remarkable results on health and longevity.

Although a short time prior to the Queen's accession, the Stockton and Darlington, the Newcastle and Carlisle, the Liverpool and Manchester, and some isolated railways had been opened and worked by locomotives, and several railways had been worked by horses before the introduction of locomotives, none of the main arterial lines had been opened; and it was not till 1837 that the Grand Junction Railway connected Liverpool with Birmingham, nor till 1838 that the London and Birmingham line was completed. The first through line from London to Scotland was not available for traffic till more than ten years after the Queen's accession, and was then dependent on ferries across the estuaries of the Forth and Tay. Practically speaking, therefore, the railway system of these islands, which was many years in advance of other countries, has been developed in the Queen's reign.

At the date of the accession, though an American ship called the *Savannah*, with small auxiliary engines, had crossed the Atlantic in 1819 in about a month, such a voyage, if attempted by vessels entirely or mainly dependent on steam, was considered by high authorities to be a mathematical impossibility. It was further held that no steamer could face the monsoon in the Red Sea, and, practically speaking, steam navigation was looked upon as only suitable for short voyages across the narrow seas, or for river navigation. In 1838 the *Great Western*, of 2300 gross and 1340 registered tonnage, designed by our past Vice-President, I. K. Brunel, demonstrated for the first time the possibility of the establishment of a regular service of steamers across the Atlantic, and the *Great Western* ran regularly between Bristol and New York for many years, the journey occupying about fourteen days. In 1845 the *Great Britain*, of 3443 gross and 2984 registered tonnage, which was the first large ocean-going steamer in the mercantile marine which was built of iron, and to which the screw-propeller was applied, also designed by Brunel, marked a further important step in advance, and she crossed the Atlantic in about twelve days. By 1840, steamers were overcoming even the dreaded monsoon in the Red Sea and Indian Ocean. Nowadays, as every one knows, the journey to New York occupies a little over five days, at an average speed of 21 knots an hour by vessels of 12,000 tons, with engines of 30,000 h.p.

The mining industry, which again is specially an engineering subject, and on which the prosperity of our country mainly depends, has during the Queen's reign made very great strides. In 1854, the total quantity of coal produced was 65 millions of tons, equal to 2·34 tons per head of population, and in 1895 the total quantity had increased to about 200 millions of tons, equal to 4·73 tons per head of population. The increase of production is continuous, and probably points to increased exports as well as to increased consumption in manufactures or traction. This large quantity of 200 millions of tons annually excavated is difficult to realise. If we assume a thickness of coal *in situ* of 6 feet, the total quantity excavated now annually would occupy nearly 21,000 acres, which is equal to twenty-five times the area.

Prior to 1851 there was no submarine cable across the Channel, none to the United States till 1858, nor to India, Australia, or South Africa till 1865, 1872, and 1879 respectively. Nowadays the mileage of submarine cables is 162,000 miles, the capital employed in them is 40 millions, and the total number of foreign and colonial telegrams is about seven millions annually, without reckoning those that are sent by the submarine companies without the intervention of the Post Office.

This brief retrospect gives some idea, however faint and imperfect, of what has been done by engineers during the past sixty years in facilitating inter-communication between individuals in this and other countries, and in the distribution of produce.

Let us now glance shortly at some of the statistics of the work of the sanitary engineer, whose work affects the duration of human life and the enjoyment of health of every individual. The mean death-rate of London for the various decades from 1840 up to 1870, when the main intercepting sewers of the metropolis were brought into use, was 24·4 per thousand. In 1880 it was reduced to 22·5, and it is now 19·5. This reduction of almost five per thousand, which means a saving of life in London alone of 22,000 individuals annually, is very largely due to the work of the sanitary engineer, though, of course, it is also to be partly accounted for by better wages, better organisation, and better medical education.

Though much of the reduction of the death-rate in towns may properly be attributed to improved sewerage, I by no means think that we ought to look to that cause as being of equal importance to an ample supply of good water. In this direction immense progress has been made during the Queen's reign, and it seems almost impossible for us now to conceive London in its condition of 1837, honeycombed with cesspools, and largely supplied with water either from surface wells, or from the Thames at Battersea or Hungerford.

Though gas for lighting was invented and began to be used prior to the accession, its cheapness and universal application to towns and large villages mark another engineering success of the reign of our Queen, and lately its application to heating purposes is a further most important step.

I have spoken of the work of engineers in railway and steamship transport, in the development of postal, telegraphic, and telephonic inter-communication and in sanitation. These indeed are important successes, but what a record there is for our profession in other labour-saving appliances—in the improvements of spinning and weaving machinery, in lace-making, in the working of iron and steel, in the invention and perfecting of hydraulic machinery—the work and success of our valued Past-President, Lord Armstrong. Hydraulic machinery has done such wonders for the use and convenience of man in every department of manufacture and trade, that it is almost impossible to conceive how even the limited amount of work of our forefathers could have been carried on without such convenient means of the transmission of power as the accumulator and high-pressure water afford.

Again, what a field has been occupied and cultivated within even the latter half of our sixty years by the electrical engineer! This subject is full of the greatest interest, but it is sufficient by itself for an address such as this, and I have no doubt it will be fully dealt with by him whom I look forward to welcoming as my successor. I have spoken shortly of telegraphs and telephones, and I can only further allude to and note the great strides already taken in the transmission of electric energy, whether it be used for traction, lighting, heating, actuation of motors, smelting of refractory metals, welding, or for electrolysis, such as in the production of aluminium or in various other branches of trade.

With regard to traction, which is a seductive subject for enlargement, I will only remark that electric traction has now passed through the experimental stages, and may be looked upon as an accomplished idea. Without entering on the question of its universal adaptability for railways in general, we can see that indisputably it is eminently fitted for any underground railway. We have the facts that the South London Railway and the Liverpool Railway have been and are being worked electrically at this moment; that a French railway company have been working a full-sized train for months between Paris and Mans by an electrically actuated locomotive, though the electricity is generated on that same locomotive, and not conveyed by a conductor; that the Baltimore and Ohio Railway Company of America has constructed and worked an electric locomotive weighing about ninety tons, actuated by electricity conveyed to it by a conductor; and that thousands of miles of tramways are worked by the same means. No doubt the application of electricity to the working of heavy trains under the exigencies of such traffic as the Metropolitan and District Railways will involve some new problems and require much consideration; but for myself I think the time has come for the work to be faced, and I am persuaded that, large as the necessary capital required may be, it will be well spent.

Before leaving the subject of the present developments of electricity, I may draw attention to the work recently inaugurated at Foyers or Loch Ness for the employment of water-power in the production of electricity for the manufacture of aluminium out of bauxite. For the production of aluminium successfully by this process with commercial success, a great deal of power must be available at a cheap rate, and water-power appears to be the only available source for such a purpose. The rainfall in this country, especially on the west coast, provides a most important agent if it can be stored cheaply at a high level, and both these desiderata are possible at Foyers, as also at other sites on the west coast. When we know that the rainfall at such places as Fort William, Ballacludish, Cumberland, and North Wales, varies from 6 feet to 7 feet per annum, and that the configuration of the country renders storage peculiarly easy, we can see that a great future may remain for the use of water-power, not only in the manufacture of aluminium, but also of acetylene and other products which may in the future attain to much importance. At Foyers the working head of water is 350 feet, and the power already developed is 3608 h.p., at an estimated cost per h.p., per annum, which is only 25 per cent. of the cost of steam-power where coal is cheap. Of course this is merely in a humble way what has been done by harnessing Niagara for commercial purposes; but this application of the forces of nature seems to me to have much promise for the future in this country.

Another most interesting subject of contemplation is the work of the engineer as applied directly to domestic life. I suppose that the invention of the lucifer match—not an engineering but chemical achievement—slightly before the beginning of the reign, but brought to mature development within its early years, was perhaps the greatest domestic boon of the century. An old friend of mine (my fishing ghilly) has described to me how, about 1839, he bought, in a then remote part of Scotland, three lucifer matches for sixpence, and exhibited them to his friends and neighbours, who naturally looked upon them with amazement and some amount of distrust as not altogether canny. The instant availability of light and heat was a stride of the greatest importance, and it is impossible to overrate it as a priceless boon for humanity. In the same way three most important home engineering feats, viz. the invention of the sewing-machine, the adaptation of machinery to the manufacture of watches and clocks, and the invention of the safety bicycle, touch and will continue to touch the home life of more individuals directly and intimately than many other engineering developments of the epoch.

Approaching now the circumstances of the present year, I think a subject of special interest at the present moment to engineers is that new departure which has been authorised by Parliament, and which may have an important bearing on the subject of intercommunication to which I have alluded—I mean the Light Railways Act, and what may be called the Auto-Motor Emancipation Act of last session.

I have little doubt that light railways will, in many districts, be of great utility, and I earnestly hope for, and fully expect, at the hands of the Commissioners appointed, a well-considered policy. Much will depend on the inauguration of the system on sound lines. I hold strongly that light railways should in all cases, other than where they will be independent approaches to a port or to a market, be of the same gauge as the standard gauge of the country. The traffic on these lines (with the above exceptions) must be dependent on the trunk or parent line, and in the nature of things will be small in each individual case.

A very important subject for consideration also in connection with the Light Railways Act, and in itself, is the future of auto-motors as applied to the light traffic, whether of goods or passengers, to be accommodated by the proposed light railways; and no engineer can read the accounts of the results attained by auto-motors, or have seen the machines in operation, without recognising their great promise for the future.

The astonishing thing is that, seeing that about the date of the Queen's accession Hancock ran his steam omnibuses regularly between Paddington and the city, and that Gurney and Scott Russell also ran auto-motors commercially about the same time, and that the subject has engaged the attention of engineers from that time to the present, resulting in various most promising auto-motors, it should be reserved for 1895 and 1896 to show so many practical vehicles. One would have thought that the force of invention, backed by public opinion, would have been sufficient before now to have compelled an alteration of the ridiculous regulations of the Acts of Parliament now happily repealed.

Without for one moment decrying the status of the able engineers who exercised their craft prior to 1837, I think it may be said that the Queen's reign has, practically speaking, witnessed the birth of engineering as a profession of a most important character, and with a great future, fulfilling duties of extreme delicacy, and bearing perhaps more responsibility in respect of life and expenditure than is supported by any other calling.

I have enlarged on the subject of the exploits and triumphs of the engineering profession, not in a spirit of boasting, as the representative for the time being of a profession to which I am proud to belong, but with the view of pointing out the dignity of our calling, and the burden laid upon us thereby, as members of this great Institution, of not letting that dignity suffer any loss or disparagement in the years to come.

In connection with the subject of the education of engineers, it is a matter of much interest to us to know what is the instruction given to engineers of other countries, and the guarantees that it has been more or less assimilated by those who are members of kindred institutions. I will only say here that I have made it my business to gain, through our Secretary, much recent information on these points, which were also investigated in 1870 at the request of the President and Council by our Honorary Member, then our Honorary Secretary, Dr. Pole. To enter into these particulars in such an address as this is impossible, and I must content myself by saying that in France, Germany, Austria, Russia, Belgium and Holland, the greatest attention is paid by the State to a strict scientific training, and that the utmost care is taken to see that all candidates for employment as engineers are, so far as education is concerned, thoroughly equipped for the work which may lie before them.

I see no proper way to ensure the same results being attained in this country except through the instrumentality of this body, which is the representative of the profession here; and I venture to think that if this Institution is to retain its present honourable position as the acknowledged head of the engineering profession of Great Britain, and of Greater Britain, we should see that any credentials or degrees conferred by us are based on undoubted qualifications.

BOTANY AT THE BRITISH ASSOCIATION.

After the delivery of the presidential address by Dr. D. H. Scott, F.R.S., an interim report was presented on the method of preserving and displaying botanical museum specimens.

An important new feature at this year's meeting was an address by the Director of the Royal Gardens, Kew, on the geographical distribution of plants. The lecture was primarily intended for those possessing a general interest in botanical science, rather than for specialists. It is hoped that the success of the experiment will lead to a continuance of such addresses at future meetings of the Botanical Section. Another interesting feature was the prominence given to two important subjects which have been matter of discussion and research for some years—the ascent of water in trees, and the problems of cell-division.

Mr. Francis Darwin, F.R.S., in opening the discussion on the former subject, contributed a paper in which the present state of our knowledge of the ascent of water was lucidly set forth, and treated from a critical standpoint. Prof. Marshall Ward discussed several of the questions raised, from a botanical aspect, with special reference to capillarity and imbibition, and particularly the structure of wood. In addition to various botanists, Prof. Fitzgerald and Dr. Joly, of Dublin, took part in the discussion, and dealt with the question mainly from the physical side. It is probable that a fuller account of the discussion will be given in a forthcoming number of the *Annals of Botany*. Mr. Darwin dealt with the subject under two main heads—the *path* of the ascending current in trees, and the *force* which produces the ascent of the water. Attention was called